

FINAL TECHNICAL REPORT

to the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SOLID EARTH AND NATURAL HAZARDS PROGRAM

NASA GRANT NAG 5-6159

**"Transients in Pacific/North American Plate Boundary Deformation:
Synthesis and Modeling of GPS and
Borehole Strain Observations"**

for the period 1 June 1997 — 14 September 2001

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Summary

This is the Final Technical Report on research conducted between 1 June 1997 and 14 September 2001 under NASA Grant NAG 5-6159, entitled "Transients in Pacific/North American plate boundary deformation: Synthesis and modeling of GPS and borehole strain observations." The investigator group includes Alan T. Linde, I. Selwyn Sacks, Paul G. Silver, and Sean C. Solomon, with important collaborative contributions from postdoctoral scientists Andrew Freed, Steven Gao, and Carolina Lithgow-Bertelloni.

As the project title implies, our effort involved a geodetic study of strain transients, i.e., temporal variations in deformation rates, that occur within plate boundary zones and their relationship to earthquakes and plate motions. Important transients occur during and following large earthquakes, and there are also strain transients not apparently associated with earthquakes. A particularly intriguing class of transients, for which there is a modest but growing list of examples, are preseismic anomalies. Such earthquake precursors, if further documented and understood, would have obvious importance for earthquake hazard mitigation. Because the timescales for these diverse transients range over at least 6 orders of magnitude (minutes to years), no single geodetic technique is optimum. We therefore undertook a systematic synthesis of Global Positioning Satellite (GPS) and borehole strainmeter data in three areas in California where there are adequate numbers of both types of instruments (or their equivalent): the San Francisco Bay region (within the Bay Area Regional Deformation network), southern California (within the Southern California Integrated GPS Network), and Parkfield (where a two-color laser system provides a proxy for continuous GPS measurements).

An integral component of our study was the elucidation of the physical mechanisms by which such transients occur and propagate. We therefore initiated the development of multiple forward models, using two independent approaches. In the first, we explored the response to specified earthquake slip in viscoelastic models that incorporated failure criteria and the geometry of major faults in California. In the second approach, we examined the dynamical response of a complex rheological medium to the application of a far-field stress imposed by plate motions. The forward models were used both to gain insight into the range of strain transients to be expected under different assumed mechanical conditions and to develop representations for strain fields that allow GPS, borehole, and other strain data to be combined in a self-consistent, yet well-determined, manner. The models also provided a basis for hypothesis testing, by which data from a strain transient well characterized by GPS and borehole observations were utilized to distinguish among competing candidates for the causative physical mechanism and the governing physical characteristics.

During the three years of this project, continued to a fourth year through a no-cost extension of the grant, we published 14 papers and presented or co-authored 37 papers at national scientific meetings. Copies of these publications and abstracts of the presentations will be provided on request.

Publications Supported by NASA Grant NAG 5-6159

1 June 1997 — 14 September 2001

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